```
from keras.preprocessing.image import ImageDataGenerator
from keras.layers import Conv2D
from keras.layers import MaxPooling2D, Dropout, Dense, Flatten

from keras.callbacks import EarlyStopping, ModelCheckpoint
from keras.models import Sequential, load_model
import tensorflow as tf
import numpy as np
import os
```

```
Using TensorFlow backend.
```

```
The default version of TensorFlow in Colab will soon switch to TensorFlow 2.x.
We recommend you upgrade now or ensure your notebook will continue to use TensorFlow 1.x via the %tens
```

```
%matplotlib inline
import matplotlib
import matplotlib.pyplot as plt

plt.rcParams['axes.labelsize'] = 16
plt.rcParams['xtick.labelsize'] = 14
plt.rcParams['ytick.labelsize'] = 14
```

```
!unzip test.zip
```

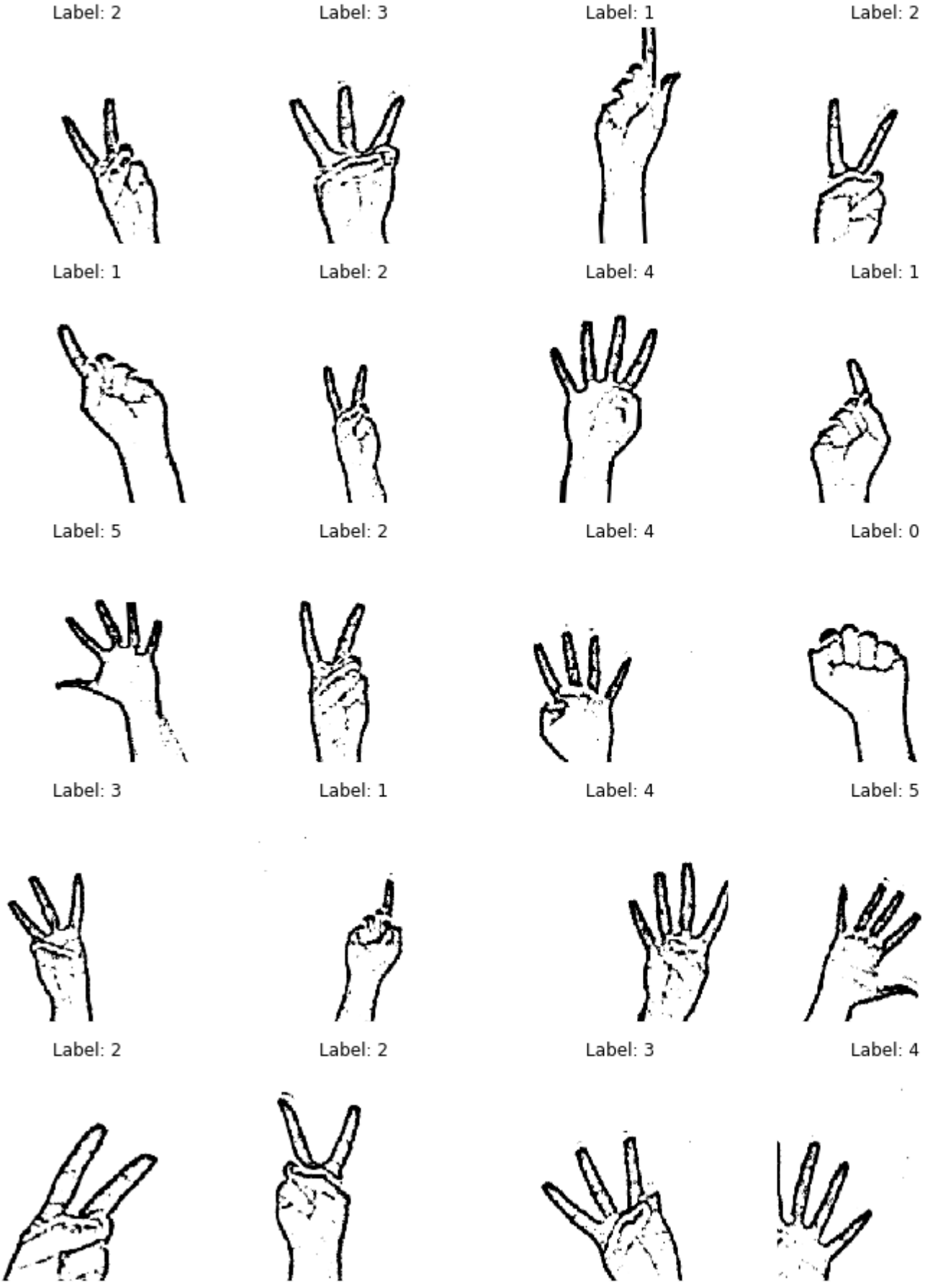
```
!unzip train.zip
```

```
nbatch = 32
train_datagen = ImageDataGenerator(rescale=1./255, rotation_range=12., width_shift_ra
                                   zoom_range=0.15, horizontal_flip = True)
test_datagen = ImageDataGenerator(rescale=1./255)

train_gen = train_datagen.flow_from_directory('train/',
                                              target_size=(256, 256),
                                              color_mode = 'grayscale',
                                              batch_size = nbatch,
                                              classes=['NONE', 'ONE', 'TWO', 'THREE',
                                              class_mode = 'categorical')
test_gen = test_datagen.flow_from_directory('test/',
                                            target_size=(256, 256),
                                            color_mode = 'grayscale',
                                            batch_size = nbatch,
                                            classes=['NONE', 'ONE', 'TWO', 'THREE', '
                                            class_mode = 'categorical')
```

```
Found 9081 images belonging to 6 classes.
Found 3632 images belonging to 6 classes.
```

```
for X, y in train_gen:
  print(X.shape, y.shape)

  plt.figure(figsize=(16, 16))
  for i in range(25):
    plt.subplot(5, 5, i+1)
    plt.axis('off')
    plt.title('Label: %d' % np.argmax(y[i]))
    img = np.uint8(255*X[i, :, :, 0])
    plt.imshow(img, cmap='gray')
  break
```

```
(32, 256, 256, 1) (32, 6)
```




```
model = Sequential()
```

```
model = Sequential()
model.add(Conv2D(32, (3, 3), activation='relu', input_shape=(256,256,1)))
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(Conv2D(64, (3, 3), activation='relu'))
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(128, (3, 3), activation='relu'))
model.add(MaxPooling2D((2, 2)))
model.add(Conv2D(256, (3, 3), activation='relu'))
model.add(MaxPooling2D((2, 2)))
model.add(Flatten())
model.add(Dense(150, activation='relu'))
model.add(Dropout(0.25))
model.add(Dense(6, activation='softmax'))

model.summary()
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens
Instructions for updating:
Please use `rate` instead of `keep_prob`. Rate should be set to `rate = 1 - keep_
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d_1 (Conv2D)            (None, 254, 254, 32)      320
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 127, 127, 32)      0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 125, 125, 64)      18496
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 123, 123, 64)      36928
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 61, 61, 64)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 59, 59, 128)       73856
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 29, 29, 128)       0
_________________________________________________________________
conv2d_5 (Conv2D)            (None, 27, 27, 256)       295168
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 13, 13, 256)       0
_________________________________________________________________
flatten_1 (Flatten)          (None, 43264)             0
_________________________________________________________________
dense_1 (Dense)              (None, 150)               6489750
_________________________________________________________________
dropout_1 (Dropout)          (None, 150)               0
_________________________________________________________________
dense_2 (Dense)              (None, 6)                 906
=================================================================
Total params: 6,915,424
Trainable params: 6,915,424
Non-trainable params: 0
_________________________________________________________________
```

```
model.compile(optimizer='adam', loss='categorical_crossentropy', metrics=['acc'])
```

```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/optimizers.p

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens
```

```
callbacks_list = [
                  EarlyStopping(monitor='val_loss', patience=10),
                  ModelCheckpoint(filepath='model_6cat.h6', monitor='val_loss', save_
]
```

```
os.environ["CUDA_VISIBLE_DEVICES"]="0"
with tf.device('/GPU:0'):
  history = model.fit_generator(
      train_gen,
      steps_per_epoch=64,
      epochs=200,
      validation_data=test_gen,
      validation_steps=28,
      callbacks=callbacks_list
  )
```

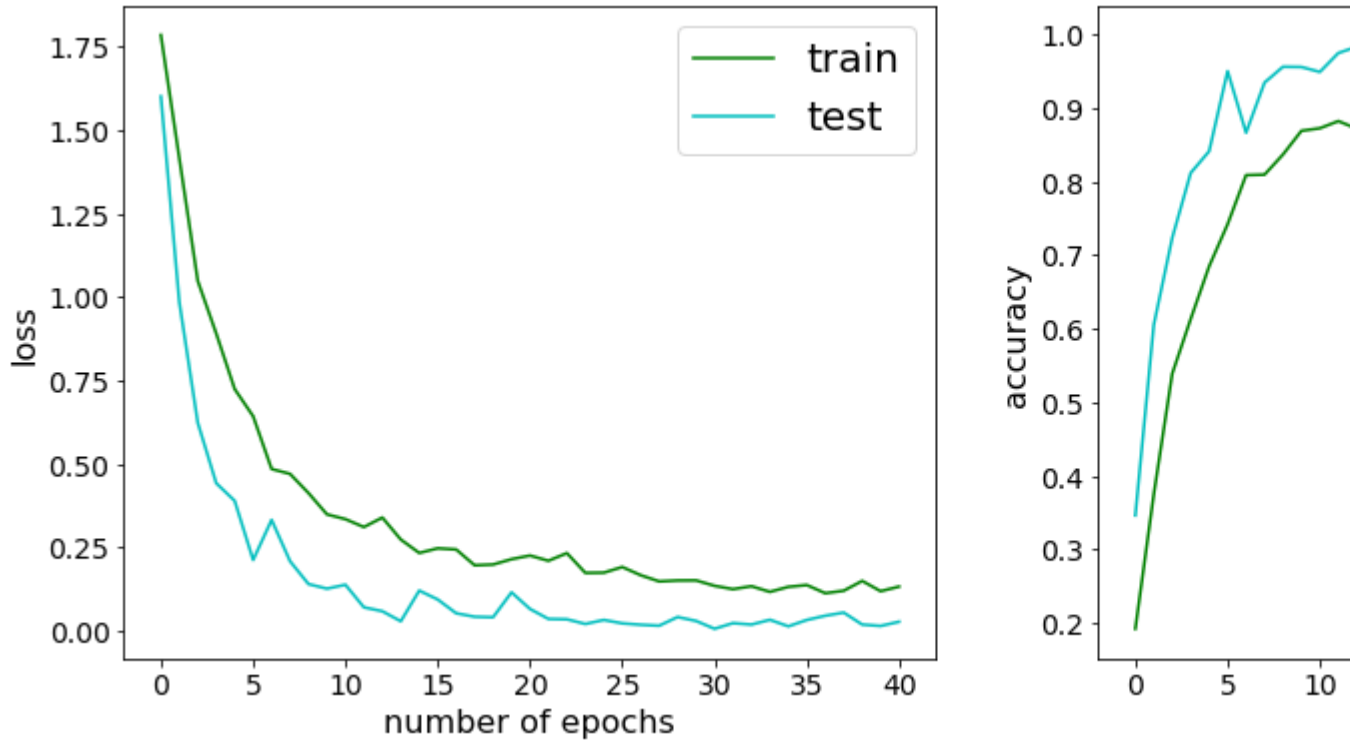
```
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/tensorflow_core/py
Instructions for updating:
Use tf.where in 2.0, which has the same broadcast rule as np.where
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

Epoch 1/200
WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

WARNING:tensorflow:From /usr/local/lib/python3.6/dist-packages/keras/backend/tens

64/64 [==============================] - 495s 8s/step - loss: 1.7845 - acc: 0.19
Epoch 2/200
64/64 [==============================] - 486s 8s/step - loss: 1.4149 - acc: 0.37
Epoch 3/200
64/64 [==============================] - 485s 8s/step - loss: 1.0475 - acc: 0.53
Epoch 4/200
64/64 [==============================] - 473s 7s/step - loss: 0.8902 - acc: 0.61
Epoch 5/200
64/64 [==============================] - 469s 7s/step - loss: 0.7234 - acc: 0.68
Epoch 6/200
64/64 [==============================] - 489s 8s/step - loss: 0.6420 - acc: 0.74
Epoch 7/200
64/64 [==============================] - 494s 8s/step - loss: 0.4839 - acc: 0.80
Epoch 8/200
64/64 [==============================] - 483s 8s/step - loss: 0.4692 - acc: 0.80
Epoch 9/200
64/64 [==============================] - 480s 8s/step - loss: 0.4117 - acc: 0.83
Epoch 10/200
64/64 [==============================] - 492s 8s/step - loss: 0.3479 - acc: 0.86
Epoch 11/200
64/64 [==============================] - 487s 8s/step - loss: 0.3344 - acc: 0.87
Epoch 12/200
64/64 [==============================] - 493s 8s/step - loss: 0.3099 - acc: 0.88
Epoch 13/200
64/64 [==============================] - 490s 8s/step - loss: 0.3384 - acc: 0.87
Epoch 14/200
64/64 [==============================] - 492s 8s/step - loss: 0.2726 - acc: 0.89
Epoch 15/200
64/64 [==============================] - 479s 7s/step - loss: 0.2323 - acc: 0.91
Epoch 16/200
64/64 [==============================] - 479s 7s/step - loss: 0.2458 - acc: 0.91
Epoch 17/200
64/64 [==============================] - 486s 8s/step - loss: 0.2428 - acc: 0.90
Epoch 18/200
```

```
64/64 [==============================] - 493s 8s/step - loss: 0.1954 - acc: 0.932
Epoch 19/200
64/64 [==============================] - 481s 8s/step - loss: 0.1976 - acc: 0.926
Epoch 20/200
64/64 [==============================] - 481s 8s/step - loss: 0.2131 - acc: 0.918
Epoch 21/200
64/64 [==============================] - 487s 8s/step - loss: 0.2246 - acc: 0.913
Epoch 22/200
64/64 [==============================] - 489s 8s/step - loss: 0.2088 - acc: 0.924
Epoch 23/200
64/64 [==============================] - 481s 8s/step - loss: 0.2318 - acc: 0.922
Epoch 24/200
64/64 [==============================] - 488s 8s/step - loss: 0.1725 - acc: 0.942
Epoch 25/200
64/64 [==============================] - 488s 8s/step - loss: 0.1732 - acc: 0.939
Epoch 26/200
64/64 [==============================] - 488s 8s/step - loss: 0.1902 - acc: 0.932
Epoch 27/200
64/64 [==============================] - 483s 8s/step - loss: 0.1655 - acc: 0.942
Epoch 28/200
64/64 [==============================] - 488s 8s/step - loss: 0.1471 - acc: 0.946
Epoch 29/200
64/64 [==============================] - 487s 8s/step - loss: 0.1498 - acc: 0.954
Epoch 30/200
64/64 [==============================] - 485s 8s/step - loss: 0.1501 - acc: 0.951
Epoch 31/200
64/64 [==============================] - 482s 8s/step - loss: 0.1338 - acc: 0.950
Epoch 32/200
64/64 [==============================] - 487s 8s/step - loss: 0.1236 - acc: 0.949
Epoch 33/200
64/64 [==============================] - 488s 8s/step - loss: 0.1326 - acc: 0.952
Epoch 34/200
64/64 [==============================] - 490s 8s/step - loss: 0.1158 - acc: 0.960
Epoch 35/200
64/64 [==============================] - 489s 8s/step - loss: 0.1308 - acc: 0.953
Epoch 36/200
64/64 [==============================] - 492s 8s/step - loss: 0.1361 - acc: 0.954
Epoch 37/200
64/64 [==============================] - 490s 8s/step - loss: 0.1116 - acc: 0.958
Epoch 38/200
64/64 [==============================] - 489s 8s/step - loss: 0.1191 - acc: 0.959
Epoch 39/200
64/64 [==============================] - 492s 8s/step - loss: 0.1485 - acc: 0.943
Epoch 40/200
64/64 [==============================] - 489s 8s/step - loss: 0.1177 - acc: 0.955
Epoch 41/200
64/64 [==============================] - 489s 8s/step - loss: 0.1313 - acc: 0.956
```

```
plt.figure(figsize=(16, 6))
plt.subplot(1, 2, 1)
nepochs=len(history.history['loss'])
plt.plot(range(nepochs), history.history['loss'], 'g-', label='train')
```

```
plt.plot(range(nepochs), history.history['val_loss'], 'c-', label='test')
plt.legend(prop={'size':20})
plt.ylabel('loss')
plt.xlabel('number of epochs')
plt.subplot(1, 2, 2)
plt.plot(range(nepochs), history.history['acc'], 'g-', label='train')
plt.plot(range(nepochs), history.history['val_acc'], 'c-', label='test')
plt.legend(prop={'size':20})
plt.ylabel('accuracy')
plt.xlabel('number of epochs')
```

```
Text(0.5, 0, 'number of epochs')
```




```
X_test, y_test = [], []
for ibatch, (X, y) in enumerate(test_gen):
  X_test.append(X)
  y_test.append(y)
  ibatch += 1
  if(ibatch == 5*28):break

X_test = np.concatenate(X_test)
y_test = np.concatenate(y_test)
y_test = np.int32([np.argmax(r) for r in y_test])

y_pred = np.int32([np.argmax(r) for r in model.predict(X_test)])
match = (y_pred == y_test)
print("Testing Acc : %.2f%%" % (np.sum(match)*100/match.shape[0]))
```

```
Testing Acc : 99.53%
```

```
from sklearn.metrics import confusion_matrix
import seaborn as sn
plt.figure(figsize=(9, 8))
cm = confusion_matrix(y_test, y_pred)
cm = cm/cm.sum(axis=1)
sn.heatmap(cm, annot=True, cmap="YlGnBu");
```